

Prosthetic Arm

LEVEL:	High School
DIVISION(S):	Grades 9 th /10 th and Grades 11 th /12 th
COMPOSITION OF TEAM:	2-3 students per team
NUMBER OF STUDENTS:	Preliminary – As determined by your local Center Regional – one team per division per Center
SPONSOR:	UCLA MESA College Prep USC MESA College Prep

OVERVIEW: Students will design, construct, and operate a simulated prosthetic arm that can grab, stack, and release plastic cups into a pyramid in the fastest time. **Participation logistics, limits, and competition facilities may vary by host site. Advisors and students are responsible for verifying this information with their center director.**



An Engineering Lab Book is a required component of this competition. The purpose of the Engineering Lab Book is for students to closely follow the practices of an engineer in the completion of their MESA Day project. The Engineering Lab Book will encourage students to take a purposeful and sustained approach to building their devices. MESA projects are not designed to be completed in a single class period or day, but to be the result of thoughtful research, planning, analysis and evaluation. The lab book should provide a written record of the thought and insight that a student put into their project, from initial ideas to the final completed project.

MATERIALS: For the device, all materials are legal with the exception of hazardous materials. There are no cost limitations; however, awards will be given to the most innovative designs utilizing low-cost materials.

Three format options are available for lab book submittals. See “*MESA DAY 19_20 General Lab Book Guidelines*” at <http://mesa.ucop.edu/>. Please check with your local center director for the format required for your preliminary event. Electronic submissions will be required at the Regional/State level.

The Host Center will provide the following:

- 21 – Red Solo Cups 16-ounce plastic cold cups from Amazon or equivalent
- Dryer Sheets – Bounce Free and Gentle

GENERAL RULES:

- 1) The students' full name, grade level, school name, and MESA Center must be clearly labeled on the device. A 10% penalty in the score will be assessed for failing to properly label.
- 2) The device must have at least two artificial fingers. These fingers:
 - a. **MUST** open and close. At least two fingers are required to move.
 - b. **MUST** grab, stack, and release the plastic cup into a pyramid. Team member may **NOT** use any other part of the prosthesis or parts of his/her own hand, wrist or arm to grab and release the plastic cup.
- 3) The device must **NOT** be controlled or operated by either of the team member's fingers, hands, or wrists.
- 4) In order to simulate an amputated arm, participating team member must have his/her wrist, hand, and fingers immobilized during the competition. The team will determine own method for immobilization.
- 5) The device (i.e., artificial fingers) may only grab, stack, and release **ONE** plastic cup at a time.
 - a. A plastic cup that is dropped on the table or floor, knocked over, knocked off the pyramid, etc. must be grabbed by the artificial fingers before attempting to replace it onto the pyramid.
- 6) During the trial, the team member may use his/her unencumbered hand (i.e., non-prosthetic) to hold and move the original pre-stack of cups, but the bottom must remain in contact with the table at all times.
- 7) Digital media (e.g., photos, video recordings, etc.) will not be accepted for arbitration purposes.
- 8) Lab books are meant to clearly demonstrate and illustrate evidence of the application of the Engineering Design Process in the MESA project.
 - a. In addition to the requirements outlined for the Engineering Lab Book, the following should be included in the **DESIGN** section:
 - i. One sketch should be of the anatomy of the human arm and the other sketches of the device. These sketches **MUST** be hand-drawn or student's original computer-generated. Sketches should indicate a progression in the thinking and design of the device and be detailed. Sketches must be no smaller than one page and can either be drawn on the lab book page directly or attached.
 - ii. The sketch of the anatomy of the human arm **AND** the sketches of the device should include the following eight required and correctly labeled structures:
 - Radius/Ulna
 - Flexor Carpi Ulnaris
 - Radiocarpal Joint
 - Carpus
 - Carpometacarpal Joint
 - Metacarpus
 - Phalanges
 - **Tendons**
 - iii. List of materials for your prototype should be listed as a **table** and include materials utilized for the above eight required structures.

Sample Materials Table

Structure	Material
Radius/Ulna	Mailing Tube
Flexor Carpi Ulnaris	Bungee cord
Radiocarpal Joint	Hinge

JUDGING:

- 1) Devices will be checked for specifications prior to the start of the competition. Disqualified teams after this initial check will have an opportunity to compete if they meet **ALL** of the following conditions:
 - a. Accept an automatic "Mistrial" and therefore no score for Trial #1.

- b. Make repairs/modifications as necessary to bring the device to proper specifications and be ready to compete when called for Trial #2.
- c. Make repairs/modifications only in the designated area as indicated by the judges.
- d. Failure to adhere to any of a, b, or c will result in the disqualification being upheld.
- 2) Teams that are not disqualified but wish to make repairs and modifications may do so, but they **MUST** be ready to compete when called for Trial #1.
 - a. Repairs are only allowed with duplicate parts and materials.
- 3) Each device will be allowed two (2) non-consecutive trials.
- 4) At the beginning of each trial, team member must demonstrate immobilization (see Rule 4).
- 5) Each device must be ready when called or team will forfeit that trial.
- 6) Each team will be given up to 60 seconds to prepare, attach, and demonstrate prosthetic arm, and to prepare the pre-stack of 21 plastic cups facing down anywhere on the table (i.e., the lips of the cup facing down). Preparing the cup stack includes treating cups with dryer sheets and placing stack cups in the preferred position. If at the end of the 60 seconds the team is not ready, the trial will be declared a mistrial and this process will be repeated for the second trial.
- 7) The judge will give the start order and begin the timer.
- 8) The team member will enter the *Working Area* and will have a maximum of 1 minute (60 seconds) to grab, stack, and release the plastic cups into the tallest pyramid. The judge will notify the team when 30 seconds, 20 seconds, and 10 seconds remain.
- 9) The judge will stop the timer when the last plastic cup has been placed onto the pyramid. Or, the judge will call “time” after one minute has passed.
 - a. The judge will record the time needed to complete the trial.
 - b. The judge will count the number cups successfully stacked on the second tier or higher (i.e. cups still stacked at the end of the trial).

SCORING:

- 1) Team points-to-time ratio = total points divided by trial time in seconds (00.00)
 - a. 20 points awarded for each plastic cup on the second tier or higher; plastic cups on the first tier will NOT earn points (maximum of 15 cups x 20 = 300 points)
 - b. Time needed to complete trial (maximum of 60.00 seconds)
- 2) Maximum of 4 points awarded for sketches and materials table
- 3) Final Score = best points-to-time ratio plus (+) sketches/table points
 - a. The best points-to-time ratio of the two trials will be used
- 4) A deduction of 20% of the final score will be assessed for an incomplete lab book and a deduction of 50% of the final score will be assessed for a missing lab book.



AWARDS:

- Awards will be given per division: Grades 9th/10th and Grades 11th/12th
- Medals will be awarded for 1st, 2nd and 3rd place based on the highest Grand Total Score.
- Ribbons will be awarded for Innovative Engineering Design utilizing low-cost materials.
- Only 1st Place teams in the Grand Total Score category in each division will advance to Regional/State MESA Day.

ATTACHMENTS/APPENDIX:

- Competition Area Specifications
- Equipment
- Engineering Lab Book Sample Mathematical Concepts
- Inspection & Score Sheet for Prosthetic Arm

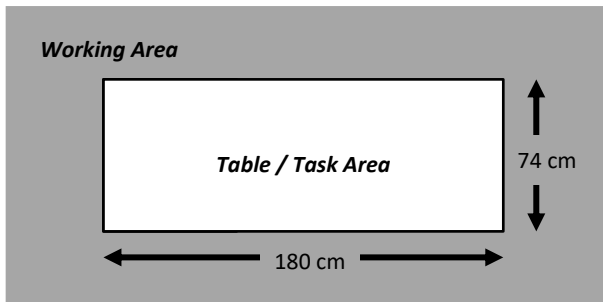
MESA DAY CONTEST RULES 2019-2020 (FINAL – REVISED 2/18/20)

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These rules are for the internal use of MESA staff and teachers only and should not be forwarded or used outside of MESA.

Competition Area Specifications

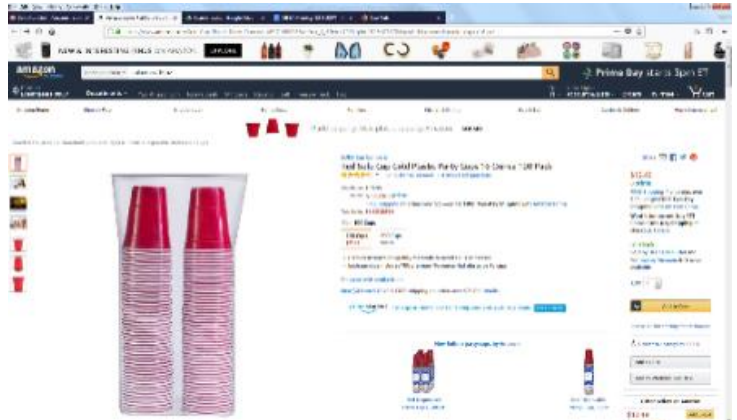
- A standard six-foot table with approximate dimensions of 180 cm (L) x 74 cm (W) x 75 cm (H).



- A perimeter of approximately one (1) meter around the table will be marked with tape. Only the team member actively participating during the trial will be permitted in this *Working Area*.

Equipment

- 21 pre-stacked Red Solo 16-ounce plastic cold cups from Amazon (Link to cups on Amazon <https://goo.gl/Rw85ga>) or equivalent recommend additional plastic cold cups as replacements)
- Standard six-foot table
- Measuring tape
- Masking tape to outline the *Working Area*
- 1 stopwatch to record trial time
- *Dryer Sheets – Bounce ‘Free and Soft’*



Engineering Lab Book Sample Mathematical Concepts

Sample concepts for the *Try It Out* section of the lab book may include the following:

- Calculate how much work is done by the artificial fingers in grabbing an object by using $W = Fd$.
- Calculate the grab and release speed of the artificial fingers by using $d = rt$.

INSPECTION AND SCORE SHEET FOR PROSTHETIC ARM

High School – Grades 9/10 and 11/12

Copies of this inspection and score sheet will be provided by the MESA Day Host Center.

Student Names: _____ Grade: **9/10** or **11/12** (circle one)

School: _____ MESA Center: _____

Section below to be completed by Judges

INSPECTION LIST:	YES	NO
Device includes at least two artificial fingers that open and close (at least 2 fingers are required to move) ..	<input type="checkbox"/>	<input type="checkbox"/>
Fingers grab and release cups	<input type="checkbox"/>	<input type="checkbox"/>
Device not controlled by fingers, hands, or wrists of either hand	<input type="checkbox"/>	<input type="checkbox"/>
Team has demonstrated immobilization of the fingers, hand, and wrist	<input type="checkbox"/>	<input type="checkbox"/>
Device labeled properly (students' full name, school name, grade and MESA Center)	<input type="checkbox"/>	<input type="checkbox"/>

Innovative Engineering Design (ranking – 1, 2, 3, etc.): _____

SKETCHES AND MATERIALS TABLE

Structure	Material Listed 0.1 points	Sketch of Arm Anatomy		Sketch of Final Device		Sub Total
		Present 0.1 points	Correctly Labeled 0.1 points	Present 0.1 points	Correctly Labeled 0.1 points	
Radius/Ulna						
Flexor Carpi Ulnaris						
Radiocarpal Joint						
Carpus						
Carpometacarpal Joint						
Metacarpus						
Phalanges						
Tendons						
TOTAL (maximum 4 points)						

TRIAL 1 # of cups: _____ x 20 = (count *ONLY* cups on second tier or higher)

 Trial Time (00.00 seconds): Cup Pts/Time Ratio: _____

Mistrial (reason): _____

TRIAL 2 # of cups: _____ x 20 = (count *ONLY* cups on second tier or higher)

 Trial Time (00.00 seconds): Cup Pts/Time Ratio: _____

Mistrial (reason): _____

Final Score (best of two trials + Sketches/Materials Table Points) _____

Device Labeling Penalty (10% of Final Score) - _____

Lab Book Penalty (20% or 50% of Final Score) - _____

GRAND TOTAL SCORE _____